DISINFECTION RULES

Rule 139(8)
Drilling water shall have a chlorine residual of not less than 10 parts per million at the time of use.

Rule 139(9)
Contractor shall notify well owner or building occupants when chlorine is placed in the water supply system.

Rule 161 (1)

- After pumping to waste, a well and pumping equipment shall be disinfected with chlorine to obtain a CT (concentration X time) relationship of 1,000 in all parts of the water supply system before pumping the well to waste and flushing out the chlorine solution.
- A contractor shall be responsible for chlorinating that portion of the water supply system on which work has been performed.

Rule 161(4)
A contractor is not responsible for redisinfecting a well or pump as a result of water samples that are collected from a location other than the sampling faucet.

More detailed information can be found in the DEQ's Disinfection Manual. It contains detailed information on various disinfection methods, chlorine sources, well preparation, and water sampling for bacteria. To receive a copy of the manual, visit the Well Construction Unit website at www.michigan.gov/deq. Click on "water", then "drinking water", then "water well construction".

PRINCIPLES OF DISINFECTION

Natural ground water from all but very shallow aquifers is considered free from pathogenic bacteria and viruses. As such, groundwater obtained from properly designed and constructed wells is generally free of disease causing bacteria, and continuous disinfection is unnecessary. However, disinfection of a new or repaired water supply system is needed to remove contaminants introduced during the construction or repair process. Existing water supplies require disinfection when routine maintenance of the system takes place, or when the results of water samples show the presence of coliform bacteria

Disinfection does not simply mean treatment of a water supply with chlorine. Disinfection involves a process of:
1. Proper water supply system preparation.
2. Flushing of the water supply.
3. Treatment with a chlorine solution.
4. Water sampling

When a new water well is drilled or an existing water well or household piping is repaired, bacteria can be introduced into the water system. Many state construction codes (for example, Part 127, 1978 PA 368, as amended, Michigan's Water Well Construction and Pump Installation Code) requires disinfection of a new or repaired water system before it is placed into service. Treatment with chlorine, combined with proper well preparation and flushing, usually eliminates the bacteria. Water well drillers and pump installers are responsible for disinfecting the work they perform. Once a properly constructed water well has been properly disinfected, it should produce safe water consistently without the need for continuous chlorination.

<u>FACTORS THAT AFFECT THE EFFECTIVENESS OF CHLORINE</u>

There are six factors that influence the effectiveness of chlorine in destroying organisms that may be present in a water supply. The factors are (1) form of chlorine, (2) pH, (3) temperature, (4) interfering substances, (5) chlorine concentration, and (6) chlorine contact time. Following is a brief discussion of these factors and their effect on disinfection.

Form of Chlorine

The form of chlorine that is in a chlorine stock solution is an important factor in how effective the solution is as a disinfectant.

Chlorine dissolved in water, regardless of whether sodium hypochlorite or calcium hypochlorite is used as the source of the chlorine, generally exists in two forms, depending on the pH of the water:

- HOCl - hypochlorous acid (biocidal)
- OCl - hypochlorite ion (oxidative)

Hypochlorous acid is 100 times more effective as a disinfectant than the hypochlorite ion. It is generally thought that the death of bacterial cells results from hypochlorous acid oxidizing essential bacterial enzymes, thereby disrupting the metabolism of the organism. In addition, hypocholous acid has a small molecular size and is electrically neutral, thereby allowing rapid penetration through a cell wall.

The hypochlorite ion is not as strong an oxidizing agent as hypochlorous acid and the negative charge of the ion impedes its ability to penetrate an organisms cell wall. Hence, the hypochlorite ion is not a s effective a disinfectant agent as hypochlorous acid.

pH

Chlorine is a more effective disinfectant at pH levels between 6.0 and 7.0, because the presence of the most effective form of chlorine, hypochlorous acid, is maximized at these pH levels. Controlling the pH of a chlorine solution increases the effectiveness of the chlorination process.

The pH determines the biocidal effects of chlorine. By controlling the pH of the solution that the chlorine is in, the form of chlorine (hypochlorous acid or hypochlorite ion) can be controlled. If the amount of hypochlorous acid, the more effective of the two forms of chlorine, can be maximized by controlling the pH, the effectiveness of the chlorine is significantly increased. The following chart demonstrates how pH affects the form of chlorine.

Effect of pH on Type of Chlorine		
	Approximate percentage at 32 to 68 degrees F	
pH	Hypochlorous Acid	Hypochlorite Ion
5	100	0
6	97-98	2-3
7	75-83	17-25
7.6	42-63	47-58
8	23-32	68-77
9	3-5	95-97
10	0	100

Chlorine will raise the pH when added to water. As noted in the chart above, raising the pH reduces the amount of hypochlorous acid present. By increasing the concentration of chlorine, and subsequently raising the pH, the chlorine solution is actually less efficient as a biocide. At higher pH levels, hypochlorite ion is formed which is the least effective of the two forms of chlorine.

Controlling the pH of the water in the aquifer is not practical. However buffering or pH-altering agents may be used to control pH in the chlorine solution being placed in the well.

Temperature

As temperatures increase, the metabolism rate of microorganisms increases. With the higher metabolic rate, the chlorine is taken into the microbial cell faster, and its bactericidal effect is significantly increased. Therefore, the higher the temperature the more likely that the chlorination of the water supply will produce the desired results.

Steam injection has been used to elevate temperatures in a well and its surrounding aquifer as a means of treating for biofouling organisms, and this process may have some application in controlling ground water temperatures (Alford, et al., 1999). However, it is limited to wells with steel casings, and the expense of the treatment generally renders it impractical for use at residential wells.

Interfering Substances
Dirty surfaces and turbid water cannot be effectively treated with chlorine. There may be substances in the water and on surfaces that bind up or use up available chlorine resulting in less chlorine (free chlorine residual) being available to serve as a disinfectant and thereby decreasing the effectiveness of the chlorination process. This binding or using up of chlorine is called chlorine demand. The interfering substances may include:

1. Inorganic matter (sand, silt, clay).
2. Organic matter (synthetic chemicals or biological material).
3. Drilling mud/additives.
4. Dissolved iron and other minerals.
5. Cuttings.

Reaction with reducing ions such as iron, manganese, nitrite, sulfide, and sulfite form the initial chlorine demand. The chlorine reduced to chlorides in these reactions has no disinfection ability. Additional chlorine will then react with ammonia and certain organic compounds to form chloro-organic compounds and chloramines. Combined residuals reach a peak, then decline as more chlorine is added, offering a limited disinfection ability. The point at which combined chlorine residuals reach a minimum and a free chlorine residual begins to appear, is known as the breakpoint. Up to this point chlorine demand (dosage minus residual) varies with dosage. Beyond the breakpoint the free chlorine residual increases directly with dosage (Jones, 1979).

But the major chlorine demand of concern in well disinfection is not in the water, but on surfaces of the well. Nuisance organisms (organisms able to reproduce in the environment of the well) often produce large quantities of organic matter. The result is a high chlorine demand and sufficient organic energy for the possible propagation of coliform if the water temperature is above 13° C (55.4° F)(Jones, 1979).

Many nuisance organisms are filamentous or slime formers and produce particles that settle to the bottom of the well, along with soil particles, scale, and other debris. It is wise to assume that 20 percent of the chlorine demand exists at the bottom of the well. In wells that have been inadequately disinfected several times, over 90 percent of the chlorine demand may be at the bottom due to settle slimes and other debris loosened in previous disinfection attempts.

Only clean surfaces in a well render themselves to effective disinfection with chlorine. Proper development of a newly constructed water supply, proper preparation of an existing water supply, and thorough flushing of a water supply can effectively clean exposed surfaces, remove turbid water, and help remove most interfering substances.

Chlorine Concentration
Exposure of an unprotected coliform organism to even very low concentrations of chlorine will kill the microorganism. However, the microorganisms may be protected from exposure to the chlorine by protective slimes, cuttings, drilling fluid, scale, etc. These interfering substances, as discussed earlier, will use up available chlorine as it tries to penetrate to make contact with the microorganism, and thus allows the microbes to survive.

The initial chlorine concentration in the chlorine solution needs to be high enough to assure that there is sufficient chlorine to make up for this “chlorine demand,” and still have a residual of chlorine left to kill the vulnerable microorganisms.

In practice, chlorine concentrations should be kept between **50 and 500 ppm**, and the standard recommended concentration is **200 ppm** (Schnieders, 2001). This allows for enough chlorine to satisfy chlorine demand (interfering substances), and still provide sufficient free available chlorine to disinfect (50 ppm). Exceeding these levels may cause damage to the well or actually reduce the effectiveness of the chlorination process as follows:

1. At higher concentrations of chlorine (in excess of 500 PPM), the corrosivity of the stock solution is significantly increased, creating a potential for damage to metal well components (submersible pumps, check valves, etc.) The use of chlorine solutions with chlorine concentrations in excess of 500 ppm is not recommended.

2. In the presence of higher concentrations of chlorine, the surface of biofilms and mineral scale may be oxidized to form a hard, tight surface (Schnieders, 2001). This sealing of the surface layers then reduces the chance that chlorine will penetrate into the material to make contact with the microorganisms that may exist there.

Contact time

"Contact time" means the amount of time that the chlorine solution is left in the water supply. Time must be provided to allow the residual chlorine to penetrate into biofilm or other materials that may be present to impact on the microorganisms in those areas.

During this period of contact time, it is essential to ensure that a chlorine residual be maintained in the water supply system for 4 to 12 hours, usually overnight.

For an increased contact time to be most effective, the pH of the chlorine solution in the well must be maintained between no lower than 6 and no higher than 7 to keep the chlorine in a nonoxidative state (hypochlorous acid).

If pH control is not going to be used during periods of increased contact time, use lower concentrations of chlorine (50 ppm or less) (Schneiders, 2001).

Generally speaking, the longer the contact time, the more likely the chlorination procedure will be successful, especially if proper concentrations of chlorine are used at controlled pH conditions.

COMMONLY USED CHLORINE SOURCES

Sodium hypochlorite and calcium hypochlorite are the most common sources of chlorine used for disinfection of on-site water supplies. The following provides information on these two chlorine sources:

<u>Sodium Hypochlorite (common household bleach)</u>

- Clear to slightly yellow colored liquid with a distinct chlorine odor.
- Common laundry bleach - 5.25 – 6.0 percent available chlorine when bottled.
  Use unscented only. Scented bleaches may leave an odor (lemon smell, etc) for extended periods of time, even after the chlorine has been flushed out of the water supply.
  Do not use bleach products that contain additives such as sulfactants, thickeners, stabilizers, and perfumes. These additives may contain hazardous chemicals and may

not be used for treatment of water supplies. Always check product labels to verify product content.

- Swimming pool chlorine - 10.0 to 12.0 percent available chlorine. Note that there are types of chlorine other than sodium hypochlorite available for swimming pool use, and these should not be used for treatment of water supplies unless certified as meeting American National Standards Institute (ANSI)/National Sanitation Foundation, Inc. (NSF) Standard 60.

  Swimming pool chlorine products may also contain UV inhibitors, algaecides, or other additives that should not be added to water supplies. Always check product labels to verify product content.
- Limited shelf life – Sodium hypochlorite solutions are of an unstable nature, due to high rates of available chlorine loss. Over a period of one year or less, the amount of available chlorine in the storage container may be reduced by 50 percent or more. Solutions more than 60 days old should not be counted upon to contain the full amount of available chlorine originally in. Because light and heat accelerate decomposition of sodium hypochlorite solutions, product degradation is less pronounced when containers are stored in a dry, cool, and darkened area, or in containers protected from light. A chlorine test kit should be used to check the final chlorine residual in a prepared chlorine solution to assure that you have the concentration intended.

As a General Rule One gallon of 5.25 percent bleach in 100 gallons of water will make a 500 part per million (ppm) solution.

Calcium Hypochlorite

- Dry white powder, granules, or tablets.
- 60 – 70 percent available chlorine.
- 12 month shelf life if kept cool and dry.
- If stored wet, looses chlorine rapidly and is corrosive

As a General Rule 3/4 lb. (1 1/2 cups) of granular calcium hypochlorite mixed in 100 gallons of water will make a 500 ppm solution.

A chlorine test kit should be used to check the final chlorine residual in a prepared chlorine solution to assure that you have the concentration intended.

Calcium Hypochlorite Tablets - The use of calcium hypochlorite tablets dropped into the top of a well is not recommended for the following reasons:

1. Tablets are designed to be slow dissolving. This characteristic is not conducive to getting all the available chlorine into the chlorine solution during the desired chlorination time interval.

2. Conditions in a well are not conducive to dissolving chlorine tablets. The water is cold and there is very little agitation or turbulence in the bottom of a well. Tablets are designed for use in applications where the water is warm and water is flowing past the tablets such as in a basket in the recirculation line of a swimming pool.

3. It is difficult to get uniform distribution of chlorine if the tablets are dumped into a well. There will be a strong concentration of chlorine around the tablets, but not in other portions of the well.

4. Tablets poured into the top of a well may lodge on the interior of the pitless adapter or on top of the submersible pump causing corrosion. Michigan Well Drilling Contractors have reported cases of severe corrosion of submersible pumps leading to premature failure.
5. The tablets cause high concentrations of chlorine in the bottom of the well, causing chemical interactions with the ground water leading to excessive scaling.

If tablets are to be used as a source of chlorine for a chlorine solution, they must first be broken up and dissolved in a 5 gallon pail or bulk tank. Otherwise, they may remain in the bottom of the well for extended time periods, and provide poor distribution of chlorine.

So which is best - sodium hypochlorite or calcium hypochlorite?
Current experiences by water well drilling contractors and ground water specialists suggest sodium hypochlorite is more effective. However, this may be associated with the quality of the ground water in the well being treated rather than with the source of the chlorine itself.

In Michigan there is an abundance of calcium based materials in both drift and bedrock wells. Calcium hypochlorite already has a high concentration of calcium (the white cloudy appearance). At 180 ppm (or approximately 10 grains of hardness), water is saturated with calcium to the point that it precipitates out of the solution, i.e., it changes from the dissolved state to a solid state.

Introducing a calcium hypochlorite solution into a calcium rich aquifer can cause the formation of a calcium carbonate (hardness) precipitate that may partially plug off the aquifer. The plugging can interfere with the effective distribution of the chlorine solution and possibly reduce the production capabilities of the well. Sodium hypochlorite does not have the tendency to create this precipitate, which may be why it appears to be a more effective disinfectant.

If the calcium carbonate concentration in the ground water is above 100 ppm (mg/l), the use of sodium hypochlorite is recommended instead of calcium hypochlorite.

NSF Certification
Sodium hypochlorite or calcium hypochlorite that contain other chemicals or additives, such as stabilizers, perfumes, or algaecides, or other chemicals that are used for water supply disinfection purposes should be certified that they are in compliance with or surpass ANSI/NSF Standard 60 for Drinking Water Treatment Chemicals – Health Effects, or an equivalent standard.

CHLORINATION METHODS

Many methods are available for the chlorination of a water well system. Although methods vary, any method employed should expose all components of the well and distribution system to a chlorine solution for an extended period of time. Consideration should be given to the well construction, type of pump and pitless adapter, corrosion of internal pump parts, potential for electric shock, exposure to fumes, and water quality concerns that may complicate the disinfection procedure. Homeowners should especially be made aware of these problems and the need for equipment or expert knowledge of well construction/pump installations which only a well driller or pump installer may possess. Consideration should also be given to possible well construction defects or possible sources of contamination causing the bacterial problems in a well.

Two methods of chlorination are commonly used – Simple Chlorination and Bulk Displacement Chlorination.

Simple Chlorination

Simple chlorination is the process of adding a small volume of chlorine solution into the top of the water well and then circulating the chlorine into the water supply's distribution system. Simple chlorination should be used for treating existing water supplies only and should **not** be used for newly constructed wells unless sampling shows the well is not the source of the bacterial contamination. And when used for treating existing wells, it should be used only for the first treatment. If this first treatment is unsuccessful in disinfecting the existing well, the bulk displacement method of well chlorination should be used for all repeat treatments. Newly constructed wells should be chlorinated using only the bulk displacement method.

Simple Chlorination Procedures

The following simple chlorination procedures are recommended for treating a typical 4- to 6-inch diameter home water well system with a submersible pump.

1. **Remove turbidity.** If the well water is not clear, pump it to waste until it clears up before starting the chlorine treatment. Turbidity (cloudiness) in the water can reduce the effectiveness of the chlorine.

2. **Bypass cartridge filters.** If the water system has a cartridge filter, place its valve in the "by-pass" position and remove the cartridge housing and cartridge. Discard the old cartridge. Rinse the housing with a solution of 1 tablespoon of bleach and a cup of water. Drain the housing and insert a new filter cartridge. Reinstall the cartridge housing and filter, but leave the cartridge filter valve on "by-pass" until the chlorine has been completely flushed from the water supply after the treatment with chlorine.

3. **Bypass other water treatment units.** By-pass all other water treatment units, such as water softeners, reverse osmosis (RO) systems, and iron removal systems. Following manufacturer's recommendations, disinfect the treatment units with chlorine. Then leave the units in "by-pass" until all chlorine has been flushed from the water supply. High concentrations of chlorine can damage softener resin, RO membranes, etc.

4. **Check water well record.** Check the water well record to see if there are packers or other devices that will prevent chlorine from reaching the water. If there are, or if you are unsure, contact a Michigan licensed water well drilling contractor to perform the treatment.

5. **Turn off power to the pump and remove the well cap.**

6. **Prepare a chlorine solution.** Prepare a chlorine solution using the table below. Any brand of **unscented** liquid household bleach that contains 5¼ percent available sodium hypochlorite may be used. **Swimming pool chlorine should be avoided.**

Chlorine Solution Table	
Well Diameter	**Amount of bleach per 25 feet of well depth**
4 inch	1 cup
5 inch	1½ cups
6 inch	2 cups

Example: A 4-inch diameter well 150 feet deep would need 6 cups of bleach to treat the well.

7. **Mix.** Mix the bleach (from above chart) with 5 gallons of clean water in a clean plastic or glass container, and add an additional 2 cups of bleach (to assure sufficient chlorine for disinfection of the pressure tank, water heater, and distribution system).

   Example: From the chart above, a 4-inch diameter well 150 feet deep would need 6 cups of bleach to treat the well. Therefore, a total of 8 cups of bleach will be mixed with the 5 gallons of water.

8. **Pour.** Slowly pour the mixture into the top of the well.

9. **Circulate.** After the chlorine solution has been applied to the well, turn the pump on and circulate the chlorinated water through the service lines and plumbing (if present). Use a hose attached to an outside tap to run the water to waste (discharge onto the ground surface) until a chlorine smell can be detected in the water, and the water is clear (i.e., there is no turbidity). Do not discharge this water into a sewage disposal system.

10. **Recirculate. Do not start this process until the water from the hose is clear.** Use the garden hose (still attached to the outside tap) to recirculate the chlorinated water back into the top of the well and wash down the inside of the casing for at least 30 minutes (the longer the better). During this process, water circulates from the pump, through the drop pipe, service line, pressure tank, distribution piping, and hose back into the top of the well. This recirculation of the chlorinated water will help assure a uniform distribution of the chlorine between the top of the water column in the well and the pump intake. In addition, all well surfaces above the water level in the well are completely flushed with the chlorinated water. The recirculation of chlorinated water enhances the chlorination process by not only exposing surfaces to chlorinated water, but also to the cleaning effect of agitated (flowing) water.

11. **Reinstall the well cap.** After the recirculation period, turn off the water to the hose and cap the well.

12. **Open taps.** Open each tap within the home, one at a time, starting closest to the pressure tank, and run water until a strong chlorine smell is present. Close the tap. Do not forget to flush each hot water tap.

13. **Contact period**. Allow the chlorine to remain in the water supply at for 4 to 12 hours, preferably overnight. Contact time is an important part of the chlorine treatment process. The longer the chlorine is allowed to remain in the water supply system, the better the

chance that the chlorine will contact and kill microorganisms that may be present. Water use during the contact time should be minimized to assure that a chlorine residual remains in the well.

14. **Flush.** After the contact period, pump to waste (flush) to remove the chlorine from the water supply. Flush until the chlorine smell can no longer be detected. After the chlorine smell can no longer be detected, it's recommended that flushing be continued for an additional 1 to 2 hours, since there may still be traces of chlorine in the well. This will help assure that **all** traces of chlorine have been removed from the system. Flushing the well for an extended period of time after treatment with chlorine will also help clean the system because of the scouring action of the water as it flows through the pipes.

    For this period of pumping to waste, use a hose connected to an outside tap, discharging into the yard, a roadside ditch, etc. If possible, avoid pumping chlorinated water on lawns and landscape plants. The outside tap should be allowed to run in the fully open position to maximize the pumping rate.

    - Do not run the water into the household plumbing, and subsequently into the septic tank/tile field, during this pumping period. This will overload the drainfield.
    - Do not run the water into a lake, stream, or other body of water.

15. **Reactivate treatment systems.** When all traces of chlorine are gone, place the already disinfected water treatment units back "on-line."

16. **Sample.** Collect a bacteriological water sample. Before sampling, a check for residual chlorine should be done using a chlorine (swimming pool) test kit. If a test kit is not available, continue to flush for at least 2 hours after there is no chlorine smell, before collecting the water sample.

Bulk displacement chlorination.

Bulk displacement is the recommended method of introducing a prepared chlorine solution into a well. This method involves preparing a predetermined volume of disinfectant solution, and then pouring or pumping this solution into a well. The chlorine solution displaces water in the casing, screen/borehole, and aquifer, replacing it with the chlorinated solution. This helps assure uniform distribution of chlorine throughout the well and the aquifer immediately around the well. This is the most practical method to assure that chlorine is effectively distributed throughout the well and surrounding aquifer. After the chlorine solution has been prepared, use the following procedures to apply it to the well:

1. **Pump to waste.** Turbidity (cloudiness) in the water can reduce the effectiveness of the chlorine. If the well water is not clear, pump it to waste until it clears up before starting the chlorine treatment.

2. **Bypass cartridge filters.** If the water system has a cartridge filter, place its valve in the "by-pass" position and remove the cartridge housing and cartridge. Discard the old cartridge. Rinse the housing with a solution of 1 tablespoon of bleach and a cup of water. Drain the housing and insert a new filter cartridge. Reinstall the cartridge housing and filter, but leave the cartridge filter valve on "by-pass" until the chlorine has been completely flushed from the water supply after the treatment with chlorine.

3. **Bypass Treatment Units.** By-pass all water treatment units, such as cartridge filters, water softeners, reverse osmosis (RO) systems, and iron removal systems. Following manufacturer's recommendations, disinfect the treatment units with chlorine. Then leave the units in "by-pass" until the chlorine has been completely flushed from the water supply after its treatment with chlorine (High concentrations of chlorine can damage softener resin, RO membranes, etc.)

4. **Application of Chlorine solution into the well using bulk displacement.** After the chlorine solution has been properly prepared (a volume of 200 ppm chlorinated water equal to 3 to 5 times the volume of the casing/bore hole), discharge the chlorine solution into the well. Assure that the wellhead area is well ventilated.

   For screened wells, the chlorine solution may be discharged directly into the top of the well. The solution will displace the water in the casing and screen, and force the chlorine solution out into the formation.

   Delivering the chlorine solution with sufficient hydraulic energy to effectively penetrate all areas of the well is crucial.

   > **For screened wells** in extremely coarse formations or where extended screen lengths are used, and for fractured or very porous rock formations, the use of a jetting tool to apply the chlorine solution is recommended. This will force the solution further out into the formation, and the jetting action will help break loose cuttings and drilling fluids that have been trapped deep into the formation.

   > **For rock wells**, the chlorine solution must be pumped through a tremie pipe extending to the bottom of the borehole, slowly withdrawing the tremie pipe as the solution is added. This will help assure that the chlorine solution is uniformly distributed throughout the entire length of the open borehole. The use of a jetting tool or other means of agitation is recommended during or after application of the chlorine solution.

5. **Agitation.** Agitation of the well is recommended when chlorinating existing wells where biofilms are likely, or where repeated chlorinations have not been successful. Agitation of the chlorine solution in the well will help assure uniform distribution of the chlorine into the aquifer, and will enhance the penetration of the chlorine into slimes, scale, or other bacteria containing material. The recommended method of agitation is by surge block or jetting tools.

7. **Circulate, recirculate, etc.** To complete the bulk displacement chlorination process, follow the procedures outlined in Items 9 thru 16 in the "Simple Chlorination" portion previously listed.

If the above method fails to produce a safe bacteriological sample, consider the possibility of a construction deficiency. This is particularly true when disinfecting an older well where the structural integrity of the system is unknown. Before employing additional methods of disinfection it is advisable to consult the local or state health department.

PREVENTING BACTERIAL CONTAMINATION

If a water well contractor is encountering a high rate of bacteriological contamination in his well installations, serious consideration should be given to (1) sanitary installation procedures, (2) chlorination of drilling water and (3) source of drilling water.

Sanitary Installation Procedures

The presence of coliform bacteria in a well is not a naturally occurring phenomenon in most Michigan aquifers. Organisms which are present in a well can be introduced during the construction phase. They can be introduced by inserting "dirty" tools, or installation of contaminated pumping equipment. The excessive use of grease and pipe dope may also contribute to difficulties by harboring bacteria and rendering them inaccessible to a chlorine solution.

Bacteria which can contaminate a water well are everywhere, and the best approach to avoiding problems is to use common sense. Attempt to keep equipment, tools and pipe as free of debris, dirt and grease as possible. Avoid using excessive amounts of pipe dope and grease on pipe joints. Store casing and screens, pitless adapters, and pumps in clean areas up off the ground. When transporting equipment used in well construction, keep it boxed until you are ready to use it. Avoid transporting casing, pumps, and drop pipe on soiled or greasy truck beds. A clean piece of new sheet plastic can be used as a ground cloth when removing drop pipe, submersible pumps or other parts from the well.

Chlorinating Drilling Water and Sources of Drilling Water

One of the most common means of introducing bacteria into a well is by use of contaminated drilling water. Part 127 or Act 368, Michigan s Ground Water Quality Control Act, specifically requires all water used in the drilling process to exhibit a chlorine residual. Chlorination of drilling water as it is introduced into a water tank helps avoid bacterial contamination problems in a well. Maintain a 10 ppm chlorine residual in all drilling waters.

Also note that bleach (sodium hypochlorite) is preferred for the disinfection of drilling water. Sodium hypochlorite will not interfere with the properties of the drilling mud. The use of calcium hypochlorites can cause some undesirable coagulation/flocculation difficulties in drilling mud.

Water used in the drilling of a well is required to be clear, chlorinated water conveyed in clean, sanitary containers. Surface water sources should be avoided. A "clear" surface water can harbor numerous organisms which can result in contamination of a well. Some of these organisms (i.e., giardia) exhibit CT's for inactivation which greatly exceed the practical chlorination requirements of a well. Always obtain drilling waters from a municipal supply or water well known to be free of bacterial contamination.

BACTERIA CLASSIFICATION

I. Nonpathogens:

- Nonpathogenic bacteria present no health threat.
- These are common background bacteria that are found in every sample we test.
- Many can be slime formers or iron oxidizers.

II. Pathogens:

- Pathogens present health dangers to all individuals.
- They must have a warm blooded host to survive.
- E. coli or fecal coliform are the most common found in groundwater.
- Cryptosporidium or Giarrdia have been the most common in surface water.
- Coliform bacteria are not actually pathogens but non-pathogens.
- They are used as indicator bacteria that E. coli (fecal coliform) bacteria <u>may be</u> present.

III. Opportunistic Pathogens

- Opportunistic pathogens present dangers to individuals with weakened health conditions.
- The elderly, young infants, and people with lower immune conditions would be susceptible to problems with these bacteria present.
- A common sub family is Pseudomonas aeruginosa which can cause lower respiratory tract infections.

PATHOGENIC BACTERIA

When E. coli/fecal coliform bacteria are present, chlorination may not be successful. These bacteria need a warm bodied source to survive. Look for the source prior to automatic chlorination:

New wells or new pump installation:

- ✓ Bailers with bird nests.
- ✓ Pumps, drop pipe, sub pump cable set on the ground.
- ✓ Stepping on drop pipe and cable prior to installation.

Existing wells:

- ✓ Loose caps on pitless adapters.
- ✓ Local of potential surface contamination (e.g. sewage systems, feed lots).
- ✓ Suspect poor grout of casing at surface.

Flush the well from the bottom with chlorinated water. Chlorine will not eliminate the warm bodied source but the flushing may.